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Predictors for Falls and Fractures in the Longitudinal Aging Study Amsterdam

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ABSTRACT

The objective of this study was to identify easily measurable predictors for falls, recurrent falls, and fractures using a population-based prospective cohort study of 1469 elderly, born before 1931, in three regions of the Netherlands. The baseline at-home interview was in 1992. In 1995, falls experienced in the preceding year and fractures over the preceding 38-month period were registered. In a period of 1 year, 32% of the participants fell at least once, and 15% fell two or more times. The rate of recurrent falls was similar in men and women up until the age of 75 years. The total number of fractures was 85, including 23 wrist fractures, 12 hip fractures, and 9 humerus fractures. The incidence density per 1000 person-years for any fracture was 25.1 (95% confidence interval [CI], 18.9–31.4) for women and 8.2 (95% CI, 4.5–12.0) for men, respectively. Multiple logistic regression identified urinary incontinence, impaired mobility, use of analgetics, and use of antiepileptic drugs as the predictors most strongly associated with recurrent falls. Female gender, living alone, past fractures, inactivity, body height, and use of analgetics proved to be the predictors most strongly associated with fractures. The probabilities of recurrent falls were 4.7% (95% CI, 2.9–7.5%) to 59.2% (95% CI, 24.1–86.9%) with zero to four predictors, respectively. The probability of fractures ranged from 0.0% (95% CI, 0.0–0.4%) without any of the identified predictors to 12.9% (95% CI, 4.4–32.2%) with all six predictors present. Our study shows that the risk of recurrent falls and of fractures can be predicted using up to, respectively, four and six easily measurable predictors. This study emphasizes the importance of impaired mobility and inactivity as predictors for falls and fractures. (J Bone Miner Res 1998;13:1932–1939)

INTRODUCTION

Falls occur often in the elderly and may lead to serious trauma. The risk of falling established in previous research varies from 28–35% per year among people aged 65 years and older who live in the community[(1–4)] and from 45–70% among people who live in nursing homes.[(5,6)] The incidence of falls is higher in women than in men and rises with increasing age.[(7,8)] About 10% of falls among elderly residing in the community results in serious injuries, with 1–2% of them resulting in hip fractures, 3–5% in fractures at other sites, and 5% in soft tissue injuries and head trauma.[(2,9–11)] Even if no physical injury occurs, frequent falls can have a serious psychological impact by inducing fear of falling, which can lead to self-imposed restrictions in activity, decreased mobility, and increased dependency.[(1,12)] The costs associated with falls and fall injuries are high, especially the cost spent on hip fractures. Fractures of the hip lead often to hospital admission and necessitate long-term rehabilitation or nursing home care.

Epidemiological studies of falls in the elderly have indicated that falls are a multicausal phenomenon with a complex interaction between intrinsic factors (e.g., advanced age, specific diseases, gait disorders) and extrinsic factors (e.g., environmental and housing conditions). In several studies,[(11,13,14)] the number of falls has been differentiated

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into recurrent falls and single or accidental falls. Single falls may primarily result from extrinsic causes, while recurrent falls are thought to be more associated with intrinsic causes.[15,16] Important predictors of falls corresponding to intrinsic causes are mobility impairment, cognitive impairment, use of medication, and postural hypotension.[2,9,14,17,18] The risk of falls increases when the number of predictors accumulates.[2]

The assessment of putative predictors for falls is necessary for the development of preventive strategies. A multidisciplinary set of predictors is essential for the prediction of falls and their consequences. The Longitudinal Aging Study Amsterdam (LASA) creates the opportunity to investigate the relationship between physical, cognitive, emotional and social functioning, and the occurrence of falls and fractures. The study of LASA is done in community-dwelling elderly men and women. Since many previous studies on falls and fall injuries have been performed in nursing homes,[2] this study will provide new information about falls and fractures in the general population of the Netherlands. The purpose of the present prospective study is to find easily measurable predictors for falls, recurrent falls, and fractures. The emphasis will be centered on simple predictors which can be measured at home without much effort. These predictors will be used subsequently to identify subgroups most at risk for recurrent falls and fractures.

MATERIALS AND METHODS

Study population

The study was conducted within the framework of LASA, a 10-year interdisciplinary cohort study on predictors and consequences of changes in autonomy and well-being in the aging population.[19] A random sample of older males and females, stratified by age, gender, and urbanization, was drawn from the population registers of 11 municipalities, in three regions of the Netherlands.

The present study on predictors for falls and fractures in the elderly was performed within a subsample of the LASA population. The subsample comprises LASA participants who were born in 1930 and before (aged 65 years and older as of 1 January 1996). The baseline data collection was performed in 1992, and the study outcomes, i.e., the occurrence of falls and fractures, were assessed in 1995. Subjects participating in the baseline examination, $n = 1722$, were eligible for participation in the follow-up study. Of these, 1508 subjects participated in the follow-up study. The response rate was 87.7%. This paper describes the results from 1469 community-dwelling subjects, 764 women and 705 men, while 39 subjects who were living in an institution were excluded from this study.

Study variables

In the baseline data collection, sociodemographic characteristics, the presence of chronic diseases, use of medication, depressive symptoms, cognitive function, physical function, level of activity and mobility, anthropometry, and other potential fall-related variables were assessed.

Sociodemographic characteristics included age, gender, educational level (ranging from one [elementary education not completed] to nine [university education]), urbanicity (ranging from one [rural] to four [highly urban]) and living arrangements (living alone or with others).

Chronic diseases reported by the participant included chronic obstructive pulmonary disease, cardiovascular disease, stroke, urinary incontinence, diabetes mellitus, joint disorders, and malignant neoplasms. Chronic diseases were verified by information of general practitioners.[20] Fractures before the baseline data collection (1992) were also recorded. Medication use was assessed by recording the participants' medications directly from the containers (regardless of whether prescribed or not). The anatomical-therapeutic-chemical[21] coding and categorization system for medications was used to classify medication.

Depressive symptoms were assessed by using the Center for Epidemiologic Studies-Depression scale (CES-D)[22] (score range, 0–60) and cognitive status was estimated by using the Folstein Mini Mental State Examination (MMSE)[23] (score range, 0–30). Participants were classified as having a cognitive impairment if their MMSE score was 24 or less[23] and were classified as depressed if their CES-D score was 16 or more.[22]

Physical function assessment included questions focusing on perception problems, functional limitations, and an expiratory peak flow test. Poor distance vision and hearing problems were ascertained by questioning the participant on whether he/she could recognize someone's face at a distance of 4 m (with glasses or contact lenses if needed) and whether he/she could follow a conversation in a group of four persons (with a hearing aid if needed). Functional limitations were considered to be present when the participant reported difficulties with at least one of the following three activities: climbing stairs, using own or public transportation, or cutting his or her own toenails. In the expiratory peak flow test, the participant was asked to expire three times as hard and as fast as possible into the peak flow instrument. The average of three tests was taken.

The level of activity and mobility included two physical performance tests and a questionnaire for the elderly which covered household activities, sports, and leisure activities.[24,25] The activities of walking outside, bicycling, and doing heavy housework were summed to a physical activity score (range, 0–3). Respondents not participating in any activity were given zero points, whereas three points corresponded to participation in all three activities. Physical performance tests included time needed to walk 3 m back and forth along a rope and time needed to stand up and sit down five times with arms crossed (chair stands). The two items were summed to a physical performance score (range, 2–8) by giving for each physical performance test a score of 1–4 points corresponding to the quartile of the distribution of time needed. The more time needed, the lower the physical performance score.[19,26]

Anthropometry included measurements of body weight, body height, and body mass index. Other potential fall-related variables included questions on presence of special fall-related adjustments at home, alcohol consumption, smoking, and questions on pain from the Nottingham

Health Profile (ranging from 5 [no pain] to 10 [severe pain]).[27]

The main outcome criterion was the occurrence of falls in the year prior to follow-up examination and fractures over a 38-month period retrospectively assessed in 1995. A fall was defined as an unintentional change in position resulting in coming to rest on the ground or other lower level such as a chair or stair.[1] For falls, two outcome variables were defined: fallers (≥1 fall) were contrasted with nonfallers, and recurrent fallers (≥2 falls) were contrasted with participants who experienced no falls or only one fall (≤1 fall).

Statistical analysis

The relationship between falls and potential predictors was examined by means of logistic regression analysis, which was performed for each predictor separately. The same procedure was followed for the analysis of fractures. In the bivariate logistic regression analysis, we identified predictors for falls, recurrent falls, and fractures. We did not adjust for age, gender, or other variables since the emphasis in this study was centered on identifying subgroups with highest risk and not on causality. The influence of gender and age on the nonresponse was checked by one-way analysis of variance. We calculated odds ratios (ORs) and 95% confidence intervals (CI) for each individual predictor of the cumulative incidences of falls and recurrent falls in the year prior to follow-up examination and fractures in the past 38 months. A risk profile for recurrent falls and fractures was obtained by multiple logistic regression (backward elimination, $p < 0.05$), retaining only the most strongly related variables. Initially, all variables that in bivariate analysis were significantly associated with recurrent falls plus age and gender were entered into the regression model for recurrent falls. A risk profile for fractures was constructed by means of the predictors that were significantly related with fractures as well as with recurrent falls plus age and gender. In the multiple regression model, each predictor is adjusted for the others, i.e., all are adjusted for age and gender. Risk profiles for recurrent falls and fractures, in which only predictors with a prevalence of above 10% were entered in the regression model (backward elimination, $p < 0.10$), were constructed in the same way. In the risk profiles of recurrent falls and fractures, ORs were transformed into estimated probabilities and corresponding 95% CIs to permit a more straightforward interpretation of the risk for recurrent falls and fractures.

RESULTS

The mean follow-up period between the baseline data collection and the registration of falls and fractures was 37.8 months (SD = 2.2). The mean age at baseline was 72.6 ± 6.6 years (range, 61.8–85.5 years). The sample included 764 women and 705 men. Of the 214 subjects who did not participate in the study, 43 (20.1%) could not participate because of severe physical and/or mental health problems, 163 (76.2%) refused, 3 (1.4%) could not be contacted, and 5 (2.3%) were deceased. Nonresponse (12.3%) was associated with gender ($p < 0.05$) and age ($p < 0.05$): the oldest and females were least likely to respond. Thirty-nine subjects who were living in an institution were excluded from this study.

TABLE 1. THE CUMULATIVE INCIDENCES OF FALLS AND RECURRENT FALLS OVER 1 YEAR FOR WOMEN AND MEN (N = 1469)

Age at baseline (years)	*Cumulative incidence of falls (%)*	*Cumulative incidence of recurrent falls (%)*
Women (n = 764)		
61–64	27.3	12.4
65–69	28.0	12.4
70–74	34.0	17.9
75–79	37.3	19.3
≥80	40.9	24.1
Total	33.4	17.1
Men (n = 705)		
61–64	36.2	12.1
65–69	21.6	10.5
70–74	30.2	14.8
75–79	31.8	12.1
≥80	31.8	12.7
Total	29.7	12.4

At least one fall had occurred during the past year in 31.6% (95% CI, 29.2–34.0) of the participants. Recurrent falls were reported by 14.8% (95% CI, 13.0–16.6) of the participants. In Table 1, the cumulative incidences of falls and recurrent falls are presented over 1 year for women and men. The cumulative incidence of recurrent falls was similar in men and women up until the age of 75 years. The difference of the cumulative incidence of falls among women and men was not significant ($p = 0.13$), whereas the percentage of recurrent falls was significantly higher among women than men ($p < 0.05$). Older age was associated with falls and recurrent falls in women, but not in men (falls, $p < 0.05$ and $p = 0.51$; recurrent falls, $p < 0.05$ and $p = 0.50$, respectively). We recorded 85 fractures, including 12 hip fractures, 23 wrist fractures, 9 fractures of the humerus, and 41 other fractures. Nine participants sustained two fractures during the follow-up period of 38 months. The incidence density for fractures was 25.1 (95% CI, 18.9–31.4) per 1000 person-years for women and 8.2 (95% CI, 4.5–12.0) per 1000 person-years for men. The incidence density per 1000 person-years for hip fractures was 3.8 (95% CI, 1.3–6.2) for women and 1.4 (95% CI, 0.0–2.9) for men.

Table 2 shows the putative predictors measured in relation to falls and fractures. Urbanicity was not associated with falls, recurrent falls, or fractures. Participants who reported one or more chronic diseases (77% of the participants) were at increased risk for falls, recurrent falls and fractures. High risks were observed for those with urinary incontinence or cardiovascular disease. Other chronic diseases, except for stroke and joint disorders, were not significantly associated with falls, recurrent falls, or fractures.

TABLE 2. PREVALENCE OR MEAN ± SD OF, ORs AND 95% CI FOR PREDICTORS FOR FALLS (≥1 FALL) (32%), RECURRENT FALLS (≥2 FALLS) (15%) IN THE PAST YEAR AND FRACTURES (16.9 PER 1000 PERSON-YEARS) IN THE PAST 38 MONTHS (N = 1469)

Predictors	Prevalence or mean ± SD	*Falls (≥1)**		*Recurrent falls (≥2)*[†]		*Fractures*	
		OR[‡]	*95% CI*[‡]	*OR*	*95% CI*	*OR*	*95% CI*
Sociodemografics (n = 1469)							
age (per 10 years)	72.6 ± 6.6 years	1.2	(1.1–1.5)[§]	1.4	(1.1–1.7)[§]	1.4	(1.0–2.0)
female gender	52%	1.2	(1.0–1.5)	1.5	(1.1–2.0)[§]	3.1	(1.8–5.4)[§]
education level (per 1 point)	3.5 ± 2.0 points	1.0	(0.9–1.0)	1.0	(0.9–1.1)	0.9	(0.7–1.0)[§]
living alone	34%	1.2	(1.0–1.6)	1.2	(0.9–1.6)	2.5	(1.6–4.0)[§]
Chronic diseases (n = 1461)							
stroke	5%	1.7	(1.1–2.8)[§]	2.2	(1.2–3.8)[§]	0.5	(0.1–2.3)
urinary incontinence	16%	1.6	(1.2–2.1)[§]	2.1	(1.5–3.0)[§]	1.9	(1.1–3.2)[§]
cardiovascular disease	26%	1.4	(1.1–1.8)[§]	1.6	(1.2–2.2)[§]	1.7	(1.0–2.7)[§]
joint disorders	38%	1.2	(1.0–1.5)	1.4	(1.0–1.9)[§]	1.2	(0.7–1.9)
chronic disease (≥1 disease)	77%	1.8	(1.4–2.4)[§]	2.4	(1.6–3.7)[§]	2.3	(1.1–4.6)[§]
past fractures (n = 1461)	28%	1.1	(0.9–1.4)	1.1	(0.8–1.5)	2.0	(1.2–3.2)[§]
Use of medication (n = 1370)							
anti-arrythmic drugs	5%	1.6	(1.0–2.7)	1.5	(0.8–2.8)[§]	2.7	(1.2–5.8)[§]
antihypertensives	17%	1.4	(1.0–1.9)	1.6	(1.1–2.3)[§]	1.2	(0.7–2.2)
antiepileptic drugs	1%	6.2	(2.0–19.7)[§]	7.1	(2.5–19.8)[§]	4.7	(1.3–17.2)[§]
analgetics	3%	1.7	(0.9–3.1)	2.9	(1.5–5.6)[§]	3.7	(1.6–8.7)[§]
sedatives	13%	1.2	(0.9–1.7)	1.4	(0.9–2.1)	1.8	(1.0–3.3)[§]
medication use (≥4 medicines)	14%	1.5	(1.1–2.1)[§]	1.4	(1.0–2.1)	1.5	(0.8–2.8)
Depression/cognitive function							
depression (n = 1452)[‖]	13%	1.6	(1.1–2.1)[§]	1.9	(1.3–2.8)[§]	1.7	(1.0–3.1)
cognitive impairment (n = 1457)[‖]	11%	1.2	(0.8–1.7)	1.1	(0.7–1.7)	1.1	(0.5–2.1)
Physical function							
vision problems (n = 1425)	16%	1.8	(1.3–2.4)[§]	1.6	(1.1–2.3)[§]	2.3	(1.3–3.8)[§]
hearing problems (n = 1464)	11%	1.5	(1.1–2.2)[§]	1.9	(1.2–2.8)[§]	0.7	(0.3–1.7)
functional limitations (n = 1448)[‖]	20%	1.9	(1.5–2.5)[§]	2.3	(1.7–3.1)[§]	1.8	(1.1–3.0)[§]
low peak flow (per 1 l/s) (n = 1355)	4.0 ± 1.3 l/s	1.1	(1.0–1.2)	1.2	(1.1–1.4)[§]	1.5	(1.2–1.8)[§]
Low level of activity and mobility							
physical activity score (per 1 point decrease) (n = 1400)[‖¶]	0.8 ± 0.9 points	1.1	(1.0–1.3)[§]	1.4	(1.2–1.7)[§]	1.5	(1.2–2.0)[§]
physical performance score (per 1 point decrease) (n = 1414)[‖‡]	6.1 ± 1.3 points	1.2	(1.1–1.3)[§]	1.3	(1.2–1.5)[§]	1.2	(1.0–1.4)[§]
Anthropometry (n = 1343)							
body weight (per 10 kg)	75.2 ± 12.5 kg	1.0	(0.9–1.0)	0.9	(0.8–1.1)[§]	0.8	(0.7–1.0)
body height (per 0.1 m)	1.67 ± 0.09 m	0.9	(0.8–1.0)	0.8	(0.7–1.0)[§]	0.8	(0.6–1.0)
Other fall-related variables							
special adjustments at home (n = 1465)	22%	1.3	(1.0–1.7)	1.2	(0.9–1.7)	1.0	(0.6–1.7)
pain (per 1 point) (n = 1071)[‖]	5.7 ± 1.3 points	1.1	(1.0–1.2)[§]	1.2	(1.1–1.4)[§]	1.4	(1.2–1.6)[§]

* "Fallers" (≥1 fall) versus "nonfallers."
[†] "Recurrent fallers" (≥2 falls) versus participants who had no falls or only one fall (≤1 fall).
[‡] OR, odds ratio; CI, confidence interval.
[§] $p < 0.05$
[‖] See Materials and Methods for definition.
[¶] Low score = inactive; high score = active.
[#] Low score = poor performance; high score = good performance.

Use of medication, especially the use of analgetics and antiepileptic drugs were strongly related to falls, recurrent falls, and fractures.

Depression was significantly associated with falls and recurrent falls, whereas cognitive impairment was not. With regard to physical activities, walking outside, bicycling, and doing heavy housework were not performed by 11, 38, and 31% of the participants, respectively. Participants with a one point lower physical activity score were at increased risk for falls, recurrent falls, and fractures. A decrease in score

TABLE 3. ODDS RATIO AND 95% CI FOR EACH PREDICTOR INCLUDED IN A RISK PROFILE, OBTAINED BY MULTIPLE LOGISTIC REGRESSION (BACKWARD ELIMINATION, $p < 0.05$), ADJUSTED FOR AGE AND GENDER, FOR RECURRENT FALLS (≥2 FALLS) ($n = 1271$) AND FRACTURES ($n = 1288$)

Predictors	*Prevalence or mean ± SD*	*OR**	*95%CI**
Recurrent falls†			
urinary incontinence	16%	1.8	(1.2–2.7)
low physical performance	6.1 ± 1.3 points	1.3–4.4‡	(1.1–8.7)‡
use of analgetics	3%	2.7	(1.3–5.6)
use of antiepileptic drugs	1%	4.7	(1.4–15.9)
Fractures			
female gender	52%	4.5	(2.0–10.0)
living alone	34%	1.8	(1.1–3.1)
past fractures	28%	1.9	(1.1–3.2)
low physical activity	0.8 ± 0.9 points	1.4–2.9§	(1.1–7.1)§
body height (per 0.1 m)	1.67 ± 0.09 m	1.5	(1.0–2.3)
use of analgetics	3%	3.2	(1.3–8.1)

* OR, odds ratio; CI, confidence interval.
† "Recurrent fallers" (≥2 falls) versus participants who had no falls or only one fall (≤1 fall).
‡ Going from 7 to 2 points in scale.
§ Going from 2 to 0 points in scale.

from 2 to 0 points in scale corresponded with a OR of 1.4–2.9 for recurrent falls. Higher risks were also observed for those with a lower physical performance score, the OR for recurrent falls ranged from 1.3–5.5 for a decrease in score from 7 to 2 points.

Increased body height was associated with a decreased risk of recurrent falls. Body weight, body mass index (mean, 26.9 kg/m^2), alcohol consumption, and smoking were not associated with falls, recurrent falls, or fractures. Participants reporting pain had a significantly increased risk for falls, recurrent falls, and fractures. However, this variable was not entered into the multivariate risk profile due to too much missing data (27.9% missing).

Table 3 shows the risk profiles including the strongest predictors for recurrent falls and fractures. Participants with none of the identified predictors had a 0.0% probability of fractures (95% CI, 0.0–0.4), whereas participants with six predictors had a 12.9% probability of fractures (95% CI, 4.4–32.2) in the risk-profile model. The probability of recurrent falls increased from 4.7% (95% CI, 2.9–7.5) without any of the identified predictors to 59.2% (95% CI, 24.1–86.9) with all four predictors present. The identified predictors of the risk profile for recurrent falls and fractures with a prevalence of above 10% are shown in Table 4. The probabilities of recurrent falls were 4.9% (95% CI, 3.1–7.8) to 12.4% (95% CI, 7.5–19.8), and the probability of fractures ranged from 0.0% (95% CI, 0.0–0.2) to 6.9% (95% CI, 2.9–15.6).

DISCUSSION

Falls and fractures are recognized as major public health problems in aging women, but there have been few epidemiologic studies in men. In contrast to most other studies, the population sample in this study includes similar numbers of men and women. Our results show that the cumulative incidence of falls did not differ among women and men. In the analyses for falls, we have distinguished fallers from recurrent fallers since recurrent falls are more likely associated with predictors based on intrinsic causes and therefore may be more amenable to therapeutic measures. The cumulative incidence of recurrent falls was significantly higher among women than men. Our findings on the incidences of falls of 32% and recurrent falls of 15% were similar to other prospective studies which reported rates of 28–35% for falls and 12–17% for recurrent falls.[2,4,14,17,28] The rate of falls leading to fractures was not registered in our study. In other studies of community-dwelling elderly, fractures occurred in about 4–7% of falls.[2,9,10,14]

Most of the putative predictors in this study were strongly related to fractures as well as to recurrent falls, although some predictors such as age, history of stroke, and joint disorders were only significantly associated with recurrent falls. We did not find a relation between fractures and age. This finding might be due to the fact that we recorded a particularly high incidence of fractures among the younger, healthier, and more active men who have an increased exposure to the risk of falls and consequently to fractures. History of stroke has been associated with an increased risk of falls. It might indirectly be associated with fractures because of a reduced bone strength due to immobility. Probably because of a low prevalence of stroke in this study, we did not find an association between stroke and fractures which is in contrast to other studies.[14,17,29] Joint disorders may have a diametrical effect on fracture risk. On the one hand, joint disorders may contribute to unstable posture and gait and may increase the risk of falls and fractures. On the other hand, the joint disorder osteoarthritis is associ-

TABLE 4. ODDS RATIO AND 95% CI FOR EACH PREDICTOR, WITH PREVALENCE > 10%, INCLUDED IN A RISK PROFILE, OBTAINED BY MULTIPLE LOGISTIC REGRESSION (BACKWARD ELIMINATION, $p < 0.10$), ADJUSTED FOR AGE AND GENDER, FOR RECURRENT FALLS (≥2 FALLS) ($n = 1261$) AND FRACTURES ($n = 1263$)

Predictors	*Prevalence or mean ± SD*	*OR**	*95% CI**
Recurrent falls†			
urinary incontinence	16%	1.8	(1.2–2.7)
low physical performance	6.1 ± 1.3 points	1.2–3.5‡	(1.1–7.4)‡
low physical activity	0.8 ± 0.9 points	1.2–1.8§	(1.0–3.4)§
Fractures			
female gender	52%	4.3	(1.9–9.8)
living alone	34%	1.8	(1.1–3.1)
past fractures	28%	1.9	(1.1–3.1)
low physical activity	0.8 ± 0.9 points	1.5–3.3§	(1.1–7.8)§
body height (per 0.1 m)	1.67 ± 0.09 m	1.6	(1.1–2.3)
vision problems	16%	1.7	(0.9–3.0)

* OR, odds ratio; CI, confidence interval.
† "Recurrent fallers" (≥2 falls) versus participants who had no falls or only one fall (≤1 fall).
‡ Going from 7 to 2 points in scale.
§ Going from 2 to 0 points in scale.

ated with a higher bone mass and consequently with a lower risk of fractures. Whether joint disorders protect against the risk of fractures remains uncertain.(30) Moreover, we did not find such relation, which is in line with several other cohort studies.(31,32)

Specific disorders including urinary incontinence and cardiovascular disease were predictors for recurrent falls as well as for fractures. These findings were confirmed by most other studies.(17,29,33) A greater number of medicines was used by fallers compared with nonfallers. Especially the use of antiepileptic drugs appears to be a strong predictor for recurrent falls and fractures in this study. However, this medication was only used by 1% of the participants. Antiepileptic drugs may influence neuromuscular function and coordination or they may not abolish all epileptic attacks. We found a strong association between the use of analgetics (paracetamol, floctafenine in 4% of the participants) and recurrent falls and fractures. In addition to the use of analgetics, the predictor pain also showed a strong association with recurrent falls and fractures. It is suggested that pain may lead to immobility and instability and consequently may increase the risk of falls and fractures. An association between cognitive impairment and recurrent falls or fractures was not found in this study, probably because cognitive impairment was less frequent in comparison with our previous study.(14) On the other side, depression was a significant predictor for recurrent falls. Gait profile and muscle strength were assessed by two physical performance tests. Our results, in line with findings from other studies,(31,34) show that performance-based measurements of physical ability are not only strong predictors for recurrent falls but also for fractures.

Six predictors were identified in the risk profile of fractures in this study. The predictors female gender, inactivity, fractures sustained in the past, and living alone were also found in other studies.(9,17,18,29,31,34,35) Contrary to the bivariate logistic regression analysis, body height was significantly associated with fractures in the multiple logistic regression analysis. Taller participants were at increased risk for fractures. A longer distance from ground level to the hip may cause a greater impact of the fall and consequently may increase the risk of fractures, especially hip fractures. Our results indicate that 0.5% of persons with no identified predictors had a risk of fracture, whereas those with six predictors had a probability of fractures of 26.9%. Identified predictors in the risk profile for recurrent falls were urinary incontinence, impaired mobility, use of analgetics, and use of antiepileptic drugs. Inactivity and impaired mobility are important predictors for falls as well as for fractures.

The risk profiles of recurrent falls and fractures are specific for our study population, community-dwelling elderly, and therefore these findings are not applicable to other populations such as institutionalized elderly. The risk profile for older, institutionalized elderly, constructed for recurrent falls in a previous study,(14) included the predictors: mobility impairment, history of stroke, cognitive impairment, dizziness, and postural hypotension. The differences in risk profiles may be explained by differences in age (mean age 73 vs. 83 years) and residence (independent vs. institutionalized elderly).

Assessment of risk profiles is important since they may help clinicians in identifying elderly at high risk for fractures and may lead to guidelines for intervention. A number of possible predictors for recurrent falls and fractures can be modified or eliminated (e.g., depression, vision problems, impaired mobility, inactivity). Other predictors (e.g., chronic diseases, history of stroke) cannot be modified; however, these predictors can identify risk groups amenable to drug treatment or to preventive measures as protective hip pads, walking aids, or environmental changes.(36–38)

Depression can be treated with antidepressive medication and psychotherapy. However, the interrelationship with other possible predictors is not completely known. Since a strong relation between depressive symptoms, functional limitations, and chronic diseases was found in another study using data from LASA,[39] the effect of the therapeutic measures is difficult to estimate. Depression may lead to visual inattention and inactivity and subsequently provoke falls.

Immobility and inactivity can be corrected to a certain extent and this decreases the incidence of falls.[40] The frequency of falls and the risk of fractures could be influenced by improvement of muscle strength and coordination in an exercise program with a moderate level of physical activity. The level of physical activity should not be too high since this is associated with an increased exposure to environmental threats and subsequently with an increased risk of injurious falls.[17,36,41]

Our study has several limitations. First, the baseline measurements were performed 3 years before the registration of falls. Changes in predictor status may have occurred during this period, especially for those predictors which are most prone to change. In the second place, the information on falls and fractures was based on data from general practitioners and self-report. There was no radiologic ascertainment of fractures. As a result, we may have misclassified some fractures, and we may have missed some falls which the participants did not report. Furthermore, the immediate cause of a fall or a fracture was not recorded.

In conclusion, the results of our study show that both the risk of recurrent falls and fractures of older persons living in the community can be predicted using up to, respectively, four and six easily measurable predictors. These risk stratifications may provide clues for prevention of falls and fractures. Some predictors can be modified to a certain extent, whereas others cannot but they may be useful for identifying patients at high risk for fractures leading to preventive drug treatment or protective measures such as hip pads. This study emphasizes the importance of impaired mobility and inactivity as predictors for falls and fractures.

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